

1 **Listing of the Claims**

2 **In the Claims:**

3 No amendment has been made to the claims, but they are listed below for the Examiner's
4 convenience.

5 1. (Original) A method for estimating a thickness of a wall of a lumen from an image of the
6 lumen, comprising the steps of:

7 (a) in an image of the lumen, identifying an inner contour and an outer contour;
8 (b) performing a low resolution triangulation function to define triangles between
9 the inner contour and the outer contour;

10 (c) adding additional triangles between the inner contour and the outer contour;

11 (d) analyzing edges of the triangles that were defined and added using a minimal
12 energy function to identify triangle edges that correspond to a width between the inner contour and
13 the outer contour; and

14 (e) comparing triangle edges identified as corresponding to a width between the
15 inner contour and the outer contour to identify a minimum width and a maximum width
16 corresponding respectively to a minimum wall thickness and a maximum wall thickness of the lumen.

17 2. (Original) The method of Claim 1, further comprising the steps of repeating steps (c) and
18 (d) until a desired resolution is achieved, such that additional triangle edges identified as
19 corresponding to a width between the inner contour and the outer contour are compared to identify
20 the minimum and the maximum width.

21 3. (Original) The method of Claim 1, wherein the step of performing the low resolution
22 triangulation function comprises the steps of:

23 (a) decomposing the inner contour into a low resolution inner contour set using
24 wavelet analysis;

25 (b) decomposing the outer contour into a low resolution outer contour set using
26 wavelet analysis; and

27 (c) computing tiling for the low resolution inner contour set and the low resolution
28 outer contour set using greedy triangulation.

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1 4. (Original) The method of Claim 1, wherein the step of analyzing the edges of the triangles
2 using the minimal energy function comprises the step of using a Delaunay triangulation MaxMin
3 angle property to determine the minimal energy function.

4 5. (Original) The method of Claim 4, wherein the step of analyzing edges of the triangles
5 using the minimal energy function further comprises the step of performing an edge flipping
6 operation on the edges of the triangles.

7 6. (Original) The method of Claim 1, wherein the step of adding additional triangles between
8 the inner contour and the outer contour comprises the steps of:

9 (a) inserting additional vertices onto each of the inner contour and the outer
10 contour, such that triangles defined between the inner contour and the outer contour are converted to
11 quadrilaterals; and

12 (b) constructing an edge from each inserted vertex on one of the inner contour and
13 the outer contour to a corresponding quadrilateral vertex on the other of the inner contour and the
14 outer contour, thereby converting each quadrilateral into a pair of triangles.

15 7. (Original) The method of Claim 1, wherein steps (a)-(e) are at least partially executed
16 automatically by a computing device.

17 8. (Original) The method of Claim 1, further comprising the step of using the inner counter,
18 the outer contour, the minimum width and the maximum width to calculate a plurality of
19 morphological descriptors for the lumen.

20 9. (Original) The method of Claim 8, wherein the step of using the inner counter, the outer
21 contour, the minimum width and the maximum width to calculate a plurality of morphological
22 descriptors comprises the step of calculating a plurality of area descriptors.

23 10. (Original) The method of Claim 9, wherein the step of calculating a plurality of area
24 descriptors comprises the steps of calculating at least two of the following:

25 (a) an area of the lumen ;

26 (b) an outer wall boundary area of the lumen;

27 (c) a wall area of the lumen; and

28 (d) a ratio of the area of the lumen to the outer wall boundary area.

29 11. (Original) The method of Claim 8, wherein the step of using the inner counter, the outer
30 contour, the minimum width and the maximum width to calculate a plurality of morphological

1 descriptors comprises the step of calculating a plurality of simple descriptors, each simple descriptor
2 being based on a one dimensional distance determined for the lumen.

3 12. (Original) The method of Claim 11, wherein the step of calculating a plurality of simple
4 descriptors comprises the steps of calculating at least two of the following:

- 5 (a) a mean of lumen boundary radii;
- 6 (b) a minimum of the lumen boundary radii;
- 7 (c) a maximum of the lumen boundary radii;
- 8 (d) a ratio of the minimum of the lumen boundary radii to the maximum of the
9 lumen boundary radii;
- 10 (e) a ratio of the minimum of the lumen boundary radii to the mean of the lumen
11 boundary radii;
- 12 (f) a ratio of the mean of the lumen boundary radii to the maximum of the lumen
13 boundary radii; and
- 14 (g) a ratio of a standard deviation of the lumen boundary radii to the mean of the
15 lumen boundary radii.

16 13. (Original) The method of Claim 11, wherein the step of calculating a plurality of simple
17 descriptors comprises the steps of calculating at least two of the following:

- 18 (a) a mean of outer wall boundary radii;
- 19 (b) a minimum of the outer wall boundary radii;
- 20 (c) a maximum of the outer wall boundary radii;
- 21 (d) a ratio of the minimum of the outer wall boundary radii to the maximum of the
22 outer wall boundary radii;
- 23 (e) a ratio of the minimum of the outer wall boundary radii to the mean of outer of
24 the wall boundary radii;
- 25 (f) a ratio of the mean of the outer wall boundary radii to the maximum of the
26 outer wall boundary radii; and
- 27 (g) a ratio of a standard deviation of the outer wall boundary radii to the mean of
28 the outer wall boundary radii.

29 14. (Original) The method of Claim 11, wherein the step of calculating a plurality of simple
30 descriptors comprises the steps of calculating at least two of the following:

1 (a) a mean of all wall thicknesses of the lumen that were determined;
2 (b) a ratio of the minimum wall thickness to the maximum wall thickness;
3 (c) a ratio of the minimum wall thickness to the mean of all wall thicknesses;
4 (d) a ratio of the mean of all wall thicknesses to the maximum wall thickness; and
5 (e) a ratio of a standard deviation of all wall thicknesses to the mean of all wall
6 thicknesses.

7 15. (Original) The method of Claim 8, wherein the step of using the inner counter, the outer
8 contour, the minimum width and the maximum width to calculate the plurality of morphological
9 descriptors comprises the step of calculating a plurality of complexity descriptors, each complexity
10 descriptor being based on two different dimensional distances determined for the lumen.

11 16. (Original) The method of Claim 15, wherein the step of calculating a plurality of
12 complexity descriptors comprises the steps of calculating at least two of the following:

13 (a) a ratio of a minimum of lumen radii to a mean of wall radii for the lumen;
14 (b) a ratio of a maximum of lumen radii to the mean of the wall radii;
15 (c) a ratio of a mean of the lumen radii to the mean of the wall radii; and
16 (d) a ratio of a distance between a centroid of the lumen and a centroid of the outer
17 wall boundary to the mean of the wall radii.

18 17. (Original) The method of Claim 15, wherein the step of calculating a plurality of
19 complexity descriptors comprises the steps of calculating at least two of the following:

20 (a) a ratio of the minimum wall thickness to a mean of wall radii;
21 (b) a ratio of the maximum wall thickness to the mean of the wall radii; and
22 (c) a ratio of the mean of all wall thicknesses to the mean of the wall radii.

23 18. (Original) The method of Claim 8, wherein the step of using the inner counter, the outer
24 contour, the minimum width and the maximum width to calculate a plurality of morphological
25 descriptors for the lumen comprises the step of calculating:

26 (a) a plurality of area descriptors;
27 (b) a plurality of simple descriptors, each simple descriptor being based on a one
28 dimensional distance determined for the lumen; and
29 (c) a plurality of complexity descriptors, each complexity descriptor being based
30 on two different dimensional distances determined for the lumen.

1 19. (Original) The method of Claim 18, wherein each morphological descriptor is
2 automatically calculated by a computing device.

3 20. (Original) The method of Claim 18, wherein the lumen is a blood vessel of a patient,
4 further comprising the step of analyzing the plurality of morphological descriptors to evaluate
5 whether the patient is at risk for having a stroke.

6 21. (Original) A memory medium on which machine executable instructions are stored for
7 carrying out the steps of Claim 1.

8 22. (Original) A method for estimating a thickness of a wall of a lumen, comprising the steps
9 of:

- 10 (a) identifying an inner contour and an outer contour of the lumen;
11 (b) generating a plurality of edges between the inner contour and the outer contour
12 using multiresolution tiling;
13 (c) analyzing the plurality of edges using a Delaunay triangulation minimal energy
14 function to identify edges that correspond to a width between the inner contour and the outer contour;
15 and
16 (d) comparing edges identified as corresponding to a width between the inner
17 contour and the outer contour to identify a minimum width and a maximum width.

18 23. (Original) The method of Claim 22, further comprising the step of using the inner
19 contour, the outer contour, the minimum width and the maximum width to calculate a plurality of
20 morphological descriptors for the lumen.

21 24. (Original) The method of Claim 23, wherein the step of using the inner counter, the outer
22 contour, the minimum width and the maximum width to calculate a plurality of morphological
23 descriptors comprises the step of calculating:

- 24 (a) a plurality of area descriptors;
25 (b) a plurality of simple descriptors, each simple descriptor being based on a one
26 dimensional distance determined for the lumen; and
27 (c) a plurality of complexity descriptors, each complexity descriptor being based on two
28 different dimensional distances determined for the lumen.

29 25. (Original) A memory medium on which machine executable instructions are stored for
30 carrying out the steps of Claim 22.

1 26. (Original) A method for estimating a thickness of a wall of a lumen, comprising the steps
2 of:

- 3 (a) identifying an inner contour and an outer contour of a lumen;
4 (b) decomposing each of the inner contour and outer contour into a low resolution
5 set of discrete points for the inner contour and a low resolution set of discrete points for the outer
6 contour;
7 (c) employing a triangulation function to define triangles between the discrete
8 points in each low resolution set;
9 (d) adding additional triangles between the inner contour and the outer contour;
10 (e) analyzing edges of the triangles that were defined and added to identify
11 triangle edges that correspond to a width between the inner contour and the outer contour;
12 (f) comparing the triangle edges to identify a minimum width and a maximum
13 width.

14 27. (Original) The method of Claim 26, wherein the step of adding additional triangles
15 between the inner contour and the outer contour comprises the steps of:

- 16 (a) inserting additional points onto each of the inner contour and the outer contour,
17 such that triangles defined between the inner contour and the outer contour are converted to
18 quadrilaterals; and
19 (b) constructing an edge from each point that was inserted to a corresponding
20 quadrilateral vertex on the other contour, thereby converting each quadrilateral into a pair of
21 triangles.

22 28. (Original) The method of Claim 26, wherein the step of analyzing triangle edges
23 comprises the step of using a Delaunay triangulation MaxMin angle property to determine a minimal
24 energy function.

25 29. (Original) The method of Claim 26, further comprising the steps of repeating steps (e)
26 and (f) until a desired resolution is achieved, such that additional triangle edges identified as
27 corresponding to the width between the inner contour and the outer contour are compared to identify
28 the minimum width and the maximum width.

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1 30. (Original) The method of Claim 26, further comprising the step of using the inner
2 contour, the outer contour, the minimum width and the maximum width to calculate a plurality of
3 morphological descriptors for the lumen.

4 31. (Original) A memory medium on which machine executable instructions are stored for
5 carrying out the steps of Claim 26.

6 32. (Original) A method for estimating a thickness of a wall of a lumen, comprising the steps
7 of:

- 8 (a) identifying an inner contour and an outer contour of the lumen;
- 9 (b) decomposing the inner contour and the outer contour into a set of low
10 resolution contours, to produce a pair of low resolution contour sets;
- 11 (c) computing tiling to generate triangles for each low resolution contour set in
12 which each triangle includes at least one cross edge extending between the inner contour and the
13 outer contour;
- 14 (d) labeling each cross edge as a suspect edge;
- 15 (e) edge flipping each triangle relative to a cross edge thereof using a minimal
16 energy function to identify cross edges that correspond to the width between the inner contour and
17 the outer contour;
- 18 (f) inserting a new vertex into each low resolution contour set, such that triangles
19 defined by the pair of low resolution contour sets are converted to quadrilaterals;
- 20 (g) constructing an edge from each inserted vertex in one of the low resolution sets
21 of the pair to a corresponding quadrilateral vertex in the other low resolution contour set of the pair,
22 to convert each quadrilateral into a pair of triangles;
- 23 (h) labeling each cross edge as a suspect edge;
- 24 (i) edge flipping each triangle relative to a cross edge thereof using the minimal
25 energy function, to identify cross edges that correspond to the width between the inner contour and
26 the outer contour;
- 27 (j) repeating steps (f)-(i) until a desired resolution is achieved; and
- 28 (k) comparing cross edges identified as corresponding to the width between the
29 inner contour and the outer contour to identify a minimum width and a maximum width.

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1 33. (Original) The method of Claim 32, further comprising the step of using the inner
2 contour, the outer contour, the minimum width and the maximum width to calculate a plurality of
3 morphological descriptors for the lumen.

4 34. (Original) A memory medium on which machine executable instructions are stored for
5 carrying out the steps of Claim 32.

6 35. (Original) A system for analyzing a lumen to determine dimensions of the lumen,
7 including wall thickness, comprising:

8 (a) imaging apparatus that produce an image of a lumen within a body of a patient;
9 and

10 (b) a computing device coupled to the imaging apparatus to control it, said
11 computing device including:

12 (i) a memory in which machine instructions are stored; and

13 (ii) a processor coupled to the memory, said processor executing the
14 machine instructions to control the imaging apparatus to carry out a plurality of operations, including:

15 (1) identifying an inner contour and an outer contour of the lumen;

16 (2) generating a plurality of edges between the inner contour and
17 the outer contour using multiresolution tiling;

18 (3) analyzing the plurality of edges using a Delaunay triangulation
19 minimal energy function to identify edges that correspond to a width between the inner contour and
20 the outer contour; and

21 (4) comparing edges identified as corresponding to a width between
22 the inner contour and the outer contour to identify a minimum width and a maximum width between
23 the inner contour and the outer contour, corresponding respectively to a minimum wall thickness and
24 a maximum wall thickness of the lumen.

25 36. (Original) The system of Claim 35, further comprising a display coupled to the
26 processor, wherein the machine instructions further cause the processor to display a discrete image of
27 a selected slice of the lumen.

28 37. (Original) The system of Claim 35, wherein the machine instructions further cause the
29 processor to calculate a plurality of morphological descriptors for the lumen, the morphological
30 descriptors including:

- 1 (a) a plurality of area descriptors;
2 (b) a plurality of simple descriptors, each simple descriptor being based on a one
3 dimensional distance determined for the lumen; and
4 (c) a plurality of complexity descriptors, each complexity descriptor being based
5 on two different dimensional distances associated with the lumen.

6 38. (Original) A system for analyzing a lumen to determine dimensions of the lumen,
7 including wall thickness, comprising:

8 (a) a computer configured to process an image of a lumen, said computer
9 including:

- 10 (i) a memory in which machine instructions are stored
11 (ii) a display configured to display an image of a lumen; and
12 (ii) a processor coupled to the memory and the display, said processor
13 executing the machine instructions to carry out a plurality of operations, including:

14 (1) in an image of the lumen, identifying an inner contour and an
15 outer contour;

16 (2) performing a low resolution triangulation function to define
17 triangles between the inner contour and the outer contour;

18 (3) adding additional triangles between the inner contour and the
19 outer contour;

20 (4) analyzing edges of the triangles that were defined and added
21 using a minimal energy function to identify triangle edges that correspond to a width between the
22 inner contour and the outer contour; and

23 (5) comparing triangle edges identified as corresponding to a width
24 between the inner contour and the outer contour to identify a minimum width and a maximum width
25 corresponding respectively to a minimum wall thickness and a maximum wall thickness of the lumen.

26 39. (Original) The system of Claim 38, wherein the machine instructions further cause the
27 processor to iteratively add additional triangles between the inner contour and the outer contour until
28 a predetermined resolution is achieved.

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1 40. (Original) The system of Claim 38, wherein the machine instructions further cause the
2 processor perform the low resolution triangulation function by implementing the following operations:

3 (a) decomposing the inner contour into a low resolution inner contour set using
4 wavelet analysis, and decomposing the outer contour into a low resolution outer contour set using
5 wavelet analysis ; and

6 (b) computing tiling for the low resolution inner contour set and the low resolution
7 outer contour set using greedy triangulation.

8 41. (Original) The system of Claim 38, wherein the machine instructions further cause the
9 processor to analyze the edges of the triangles using a Delaunay triangulation MaxMin angle property
10 to determine the minimal energy function

11 42. (Original) The system of Claim 38, wherein the machine instructions further cause the
12 processor to analyze triangle edges by performing an edge flipping operation on the edges of the
13 triangles.

14 43. (Original) The system of Claim 38, wherein the machine instructions further cause the
15 processor to add additional triangles between the inner contour and the outer contour by implementing
16 the following operations:

17 (a) inserting vertices onto each of the inner contour and the outer contour, such that
18 triangles defined between the inner contour and the outer contour are converted to quadrilaterals; and

19 (b) constructing an edge from each inserted vertex on one of the inner contour and
20 the outer contour to a corresponding quadrilateral vertex on the other of the inner contour and the outer
21 contour, thereby converting each quadrilateral into a pair of triangles.

22 44. (Original) The system of Claim 38, wherein the machine instructions further cause the
23 processor to calculate a plurality of morphological descriptors for the lumen, the morphological
24 descriptors including:

25 (a) a plurality of area descriptors;

26 (b) a plurality of simple descriptors, each simple descriptor being based on a one
27 dimensional distance determined for the lumen; and

28 (c) a plurality of complexity descriptors, each complexity descriptor being based on
29 two different dimensional distances determined for the lumen.
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